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Abstract

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Fish richness and abundance in created riparian habitats of channelized northern Mississippi streams. By Peter C. Smiley Jr., Scott S. Knight, Charles M. Cooper and Kenneth W. Kallies

Keywords

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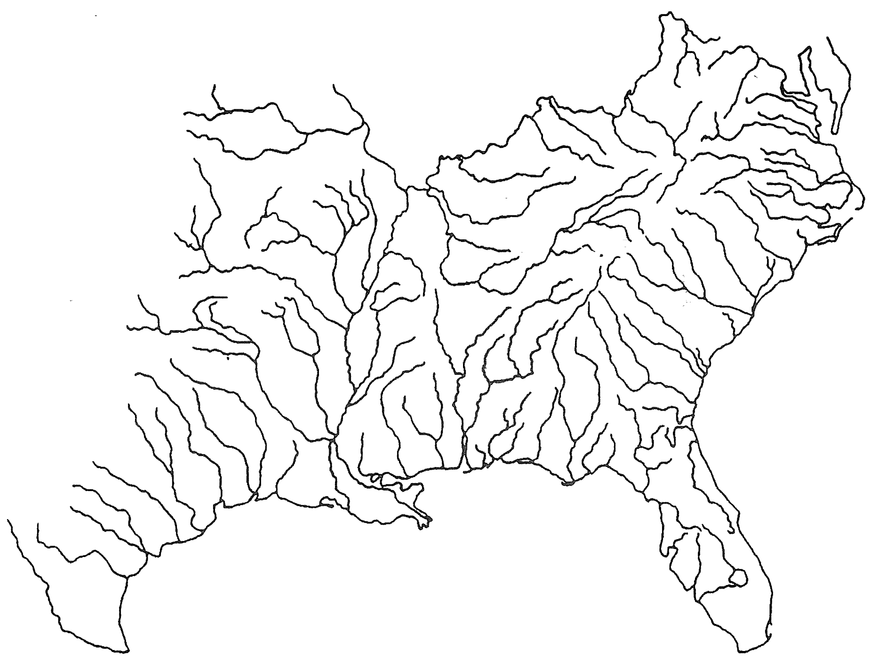

Contents

Instantaneous Growth and Mortality of Alevin Channel Catfish *Ictalurus punctatus* (Siluriformes: Ictaluridae) in the Oconee River, Georgia

CARL R. RUETZ III[1]
Georgia Cooperative Fish and Wildlife Research Unit, Daniel B. Warnell School of Forest Resources, University of Georgia, Athens, Georgia 30602

CECIL A. JENNINGS[2]
United States Geological Survey, Biological Resources Division, Georgia Cooperative Fish and Wildlife Research Unit, Daniel B. Warnell School of Forest Resources, University of Georgia, Athens, Georgia 30602

ABSTRACT

We estimated instantaneous growth (G) and mortality (Z) rates of alevin channel catfish (*Ictalurus punctatus*) from the Oconee River, Georgia. We modeled growth and mortality with exponential equations and estimated G and Z with regression techniques. These efforts produced mixed results. Our estimate of G (0.0064; SE = 0.0012) was significantly different from zero ($P = 0.013$), whereas our estimate of Z was not different from zero ($P = 0.35$). If we assume that the estimated growth model was appropriate for larger young-of-the-year channel catfish, we predict that they would be 25 mm total length by mid-September. This size is smaller than that (i.e., ~60 mm) reported for similarly-aged alevins in other systems. Mechanisms responsible for the apparently low growth of alevin channel catfish in the Oconee River are unclear.

INTRODUCTION

Estimates of growth and mortality for young-of-the-year (YOY) fishes are essential for understanding fish population dynamics. If these estimates were made regularly, biologists could assess extrinsic factors that are correlated with growth and mortality of YOY fishes (Hatch and Underhill, 1988). Growth and mortality estimates for adult freshwater fishes are common; however, such estimates are rare for early life stages, even though these life stages are thought to dictate eventual year-class strength and could be used to predict recruitment (Cada and Hergenrader, 1980; Crecco et al., 1983). Thus, growth and mortality studies represent a significant first step toward understanding the early life history of fishes and how life history is affected by environmental conditions. For example, growth rates of fish are sensitive to physical and biological factors such as water quality and fish density (Freeberg et al., 1990; Brandt et al., 1992).

The channel catfish (*Ictalurus punctatus*) is a parental care species, and development of early life stages differs from the typical progression of yolk-sac larvae, larvae, and pre-juvenile phases found in most other fishes. Spawning occurs in dark, secluded nests usually between May and July when water temperature is about 21 - 30 C, with 27 C being optimum (Lippson and Moran, 1974; Jenkins and Burkhead, 1993). Males often build nests in burrows, undercut banks, log jams, or rocks, and guard the newly-hatched fish (6 - 9 mm total length; TL) until they leave the nest 7 or 8 days post-hatching (Lippson and Moran, 1974; Tin, 1982). The larval period, defined as the phase between yolk absorption and acquisition of adult fin ray complements, is absent from the development of ictalurids because adult fin ray complements are evident at yolk absorption (Jones et al., 1978; Tin, 1982). This early juvenile phase that begins after yolk absorption is termed alevin (Balon, 1975).

Population dynamics of alevin channel catfish have not been well studied even though the species is of considerable economic and recreational importance throughout North America. Our research goal was to present data on the seasonal occurrence and abundance of alevin channel catfish in the Oconee River, Georgia, along with estimates of instantaneous growth and mortality for this life stage.

METHODS

Study Area

Alevin channel catfish were sampled from a 4-km reach of the Oconee River, Georgia, located between the Central of Georgia Railroad bridge (at Wilkinson-Washington County line) and Commissioner Creek (in Wilkinson County). The Oconee River is a tributary of the Altamaha River, and the study reach was located in the Upper Coastal Plain physiographic province. Hydropower generation by Sinclair Dam, located at Milledgeville about 55 km upstream from the study site, resulted in an unpredictable, highly variable flow regime in the river. The mean daily discharge at a U.S. Geological Survey water stage recorder (No. 02223248), located about 4.4 km

[1]Present address: Minnesota Cooperative Fish and Wildlife Research Unit, 200 Hodson Hall, 1980 Folwell Ave., University of Minnesota, St. Paul, Minnesota 55108.

[2]Corresponding author.

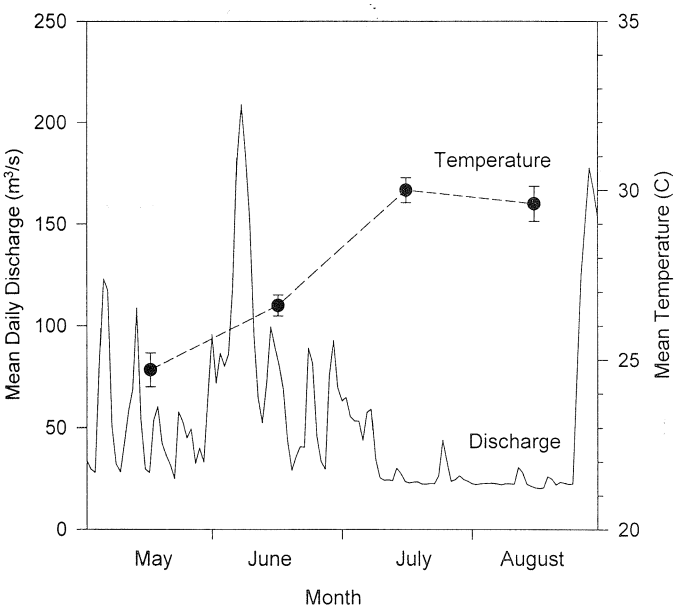

Figure 1. Mean daily discharge (m^3/s) calculated from a water-stage recorder located in the Oconee River, Georgia, about 4.4 km downstream of Commissioner Creek from 1 May to 31 August 1995 (Stokes and McFarlane 1995). Mean (± 1 SE) water temperature for each month measured during sample collection from 10 May to 21 August 1995.

downstream from the study site, ranged from 23 to 209 m^3/s between May and August (Stokes and McFarlane, 1995); however, mean daily discharge does not represent diel variation associated with generation (Fig. 1). The study reach was shallow (mean depth = 1.7 m; SD = 0.9) with moderate current velocity (mean = 0.32 m/s; SD = 0.09) in the thalweg (i.e., path of deepest water) of the river. Mean monthly dissolved oxygen concentrations ranged from a low of 6.7 mg/L during May to a high of 7.3 mg/L during July. Mean monthly water temperature increased from May to July, with minimal variation in July and August (Fig. 1). Water temperatures and dissolved oxygen concentrations were within the range required for adult channel catfish survival and spawning.

Sample Collection And Processing

Alevin channel catfish were sampled at least once weekly from 10 May to 21 August 1995. Water temperature, dissolved oxygen concentration, current velocity, and water depth were measured at the time of sample collection. A 505-μm-mesh pushnet (area = 0.20 m^2) was used to sample alevins in the surface drift (depth = 0.0 - 0.5 m) and a 800-μm-mesh modified D-ring net (area = 0.34 m^2) was used to sample the drift at the river bottom. Samples were collected in the thalweg of the river at nighttime when alevin channel catfish are most common in the drift (Armstrong and Brown, 1983; Brown and Armstrong, 1985; Holland-Bartels and Duval, 1988). The mouth of each net was equipped with a flow meter so that the volume of water sampled could be calculated. Nets were fished until about 100 m^3 of water was sampled (pushnet ~ 12 min; D-ring net ~ 10 min). Twelve samples (i.e., six with each gear) were collected during a sampling occasion. All samples were preserved in 10% buffered formalin.

In the laboratory, alevins were enumerated and placed in vials for later identification. Extraction efficiency, estimated by re-examining 20% of the sample residues, averaged 99.5% (SD = 3.1). Identification of ictalurids was based on morphometric and meristic descriptions (Lippson and Moran, 1974; Jones et al,. 1978; Cloutman, 1979; Wang and Kernehan, 1979; Tin, 1982). Channel catfish alevins in each sample were measured to the nearest 0.1 mm TL with dial calipers and assigned to 1-mm size classes (e.g. 14.0 - 14.9 mm TL). Catch data were expressed as a density (i.e., numbers of fish per 1,000 m^3 of water sampled).

Growth and Mortality Estimation

Instantaneous growth and mortality were estimated with a length-based method developed by Hackney and Webb (1978) that has been used successfully to estimate these parameters for larval fishes (Cada and Hergenrader, 1980; Hatch and Underhill, 1988; Zigler and Jennings, 1993). Catch data for pushnets and D-ring nets were pooled to develop estimates of instantaneous growth and mortality because both gear types were used during a sampling event to better represent alevins in the drift (i.e., upper and lower portion of the water column). Size classes with less than five fish were excluded from analyses because undue variation could be introduced by the small sample size (Van Den Avyle, 1993).

Growth rates were estimated by calculating a density-weighted mean date of collection for each 1-mm size class (Hackney and Webb, 1978). The density-weighted mean date (D) for each size class was estimated with the equation

$$D = \frac{\sum_{i=1}^{n} d_i J_i}{\sum_{i=1}^{n} d_i}, \qquad i = 1,2,\ldots,n \tag{1}$$

where d_i was the alevin density for each collection date of a 1-mm size class, J_i was the Julian collection date, and n was the number of sampling occasions. Age was calculated for each 1-mm size class by subtracting the density-weighted mean date of the smallest size class collected from each of the subsequent size classes (Hackney and Webb, 1978). The age of the smallest size class examined was estimated to be zero. Instantaneous growth was estimated with the equation

$$\log_e(L_t) = \log_e(L_0) + Gt, \tag{2}$$

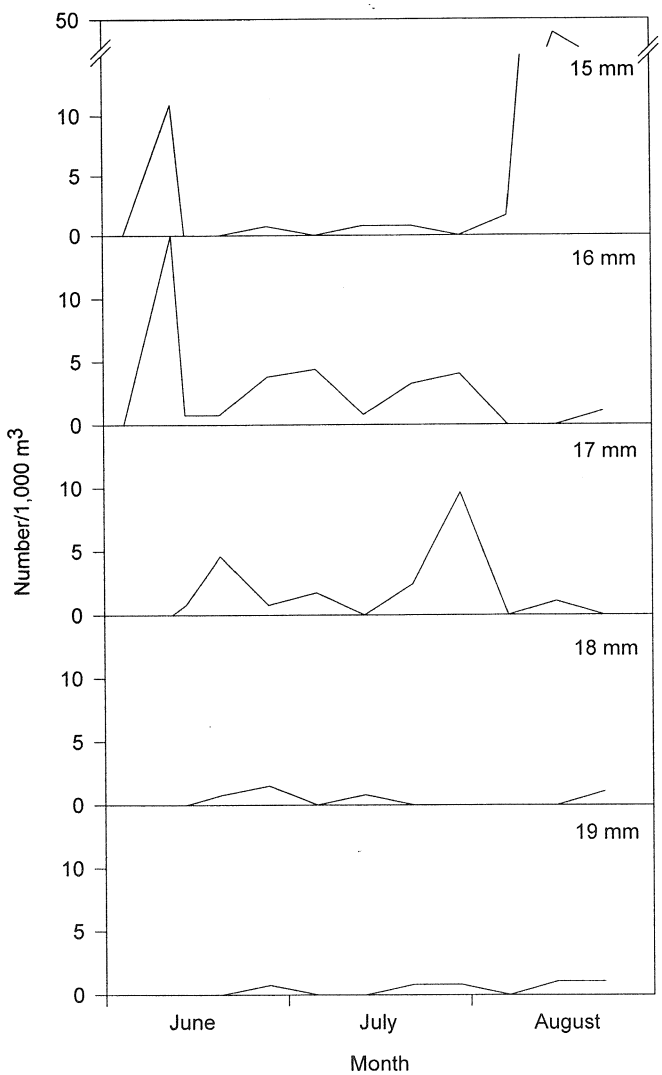

Figure 2. Density of selected 1-mm size-classes of channel catfish alevins collected by push-nets and D-Ring nets in the Oconee River, Georgia, from 10 May to 21 August 1995.

where L_t was the TL (mm) of the lower limit of each size class, L_0 was the length intercept, G was the coefficient of instantaneous growth, and t was age in days (Hackney and Webb, 1978). Instantaneous mortality was estimated with the equation

$$\log_e(N_t) = \log_e(N_0) - Zt, \tag{3}$$

where N_t was the predicted alevin abundance at age t, N_0 was the alevin abundance axis intercept, Z was the coefficient of instantaneous mortality, and t was age in days (Hackney and Webb, 1978). The mortality estimate was based on the descending limb of the catch curve to reduce gear bias from underrepresented small size classes that had not yet recruited to the sampling gear (Ricker, 1975). The portion of the descending limb of the catch curve used to estimate instantaneous mortality was shifted one size class to the right of the size class that occurred at the highest frequency (i.e., dome) because the dome of the catch curve may or may not be vulnerable completely to the sampling gear (Everhart and Youngs, 1981). Statistical significance of the slope of regression lines was assessed by treating values of $P < 0.05$ as significant.

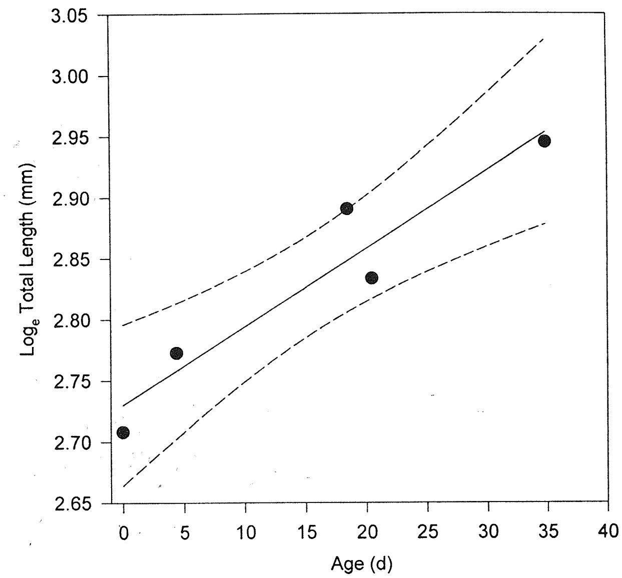

Figure 3. Estimated growth for selected age-groups of channel catfish collected by push-nets and D-Ring nets in the Oconee River, Georgia, from 10 May to 21 August 1995. The dashed lines represent the upper and lower 95 % confidence limits for regression estimates. Alevins from the second spawning peak were omitted from age and growth analyses.

RESULTS

Channel catfish were not collected in the drift until mid-June. One hundred sixty-four alevin channel catfish (14.0 - 22.9 mm TL) were collected from 19 June to 21 August 1995, and the mean density of these alevins in the catch was 13 fish per 1,000 m^3 of water sampled (SE = 0.03). Channel catfish recruited to drift nets at about 15 mm TL. Alevin channel catfish relative abundance was bimodal, attributed to two spawning peaks, one during late June and another during mid-August (Fig. 2). Each size class of fish less than 22 mm TL from the first spawning peak was represented in the collection. Channel catfish less than 17 mm TL collected on 14 and 21 August were excluded from estimates of growth and mortality because fish collected at these dates represent a second spawning peak. Cohorts from the second spawning peak were described incompletely because sampling ended during August, before abundance of most 1-mm size classes had peaked.

The range of fish lengths used to estimate growth was 15 - 19 mm TL. Regression analysis showed that the relationship

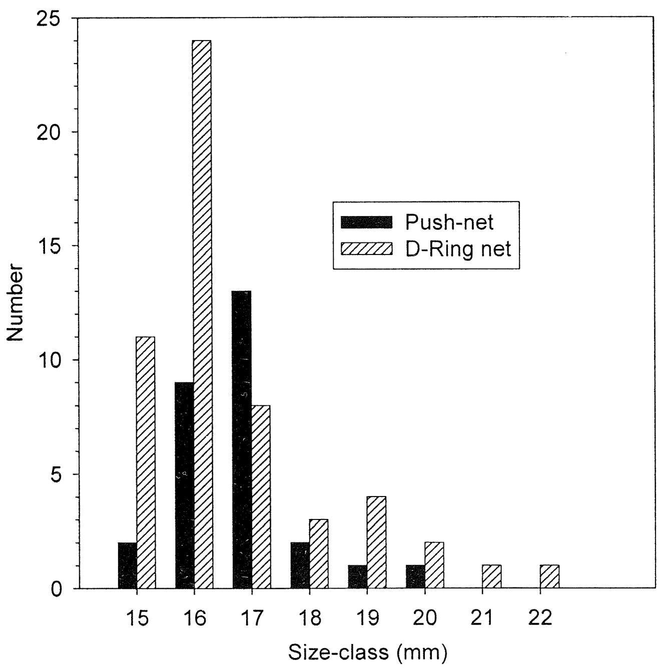

Figure 4. Number of channel catfish in each 1-mm size-class collected by push-nets and D-Ring nets in the Oconee River, Georgia, from 10 May to 21 August 1995. Alevins from the second spawning peak were omitted from the catch curve analysis.

between natural logarithm of channel catfish TL and age was significant ($r^2 = 0.91$; $P = 0.013$). The coefficient of instantaneous growth, estimated as the slope of the regression line, was 0.0064 (SE = 0.0012), and the complete growth equation was $\log_e(L_t) = 2.7 + 0.0064t$ (Fig. 3).

Fish less than 17 mm TL or greater than 19 mm TL were not used to estimate mortality because these size classes were sampled incompletely. Fish less than 16 mm TL, which should have been the most abundant, were underrepresented in the alevin catch (Fig. 4). The relationship between the natural logarithm of channel catfish abundance and age was not significant ($r^2 = 0.72$, $P = 0.35$). Nonetheless, instantaneous mortality, calculated as the slope of the regression line, was 0.089 (SE = 0.055).

DISCUSSION

Considerable information is available about growth and mortality of adult channel catfish (e.g., Carlander, 1969), but few such data exist for alevin channel catfish or other ictalurids. Nonetheless, the estimated instantaneous growth of alevin channel catfish in the Oconee River seems low because the estimate is an order of magnitude lower than published estimates of instantaneous growth for other fishes. If we assumed that the estimated growth model was appropriate for larger YOY fish through mid-September, we predict that channel catfish would be about 25 mm TL in mid-September. This size is smaller than lengths reported in mid-September for YOY channel catfish in riverine habitats in Wisconsin (67 mm TL; Becker, 1983) and the upper Mississippi River (60 mm TL; McInerny and Held, 1995). McInerny and Held (1995) collected fish from cooling water intake screens of a power plant, whereas the collection method used by Becker (1983) was not reported. Thus, the method we used to collect channel catfish differed from those used by McInerny and Held (1995), and size selectivity of the different sampling methods may have varied. Gear avoidance by channel catfish greater than 16 mm TL would artificially reduce our estimate of instantaneous growth. However, relative abundance of channel catfish greater than 16 mm TL in trawl collections was correspondingly low (Jennings, unpublished data), which suggests that avoidance by larger channel catfish to drift nets was not a likely explanation for the low instantaneous growth rate we observed in the Oconee River. Holland-Bartels and Duval (1988) showed that a trawl similar to ours was effective for collecting YOY channel catfish (15 - 70 mm standard length) in the upper Mississippi River.

Assumptions common for estimates of growth and mortality are similar to those derived by Ricker (1975) for use in traditional catch-curve analysis. These assumptions are: 1) mortality and growth rates are constant with age, 2) cohorts initially recruit to the sampling gear at about the same length, and 3) all size classes of cohorts used for estimates are equally vulnerable to sampling gear (Essig and Cole, 1986). We limited the length distribution of alevins in growth and mortality estimates to minimize violating the assumption that growth and mortality were constant with age and that all size classes of cohorts used for estimates were equally vulnerable to sampling gear. We also sampled at nighttime to minimize gear avoidance and used two different gear types to better represent alevins in the drift.

The number of alevin channel catfish we used to estimate instantaneous growth and mortality is smaller than the number of fish used in other growth and mortality studies (Hatch and Underhill, 1988; Zigler and Jennings, 1993). However, our sampling periodicity was similar to Cada and Hergenrader (1980), Hatch and Underhill (1988), and Zigler and Jennings (1993), and the time period we sampled (10 May - 21 August 1995) should have been sufficient to encompass the theoretical spawning season of channel catfish (Marzolf, 1957; Brown and Armstrong, 1985). Therefore, the low number of alevin channel catfish we collected probably was due to their low densities in the drift (13 alevins/1,000 m^3). We took several precautions outlined by Ricker (1975), Everhart and Youngs (1981), and Van Den Avyle (1993) to reduce the effects of sampling bias in our analyses. Further, we avoided small sample bias by limiting our analyses to size classes with at least five fish (Van Den Avyle, 1993).

The presence of two spawning peaks, the first in late June and second in mid-August, was apparent from the catch of alevins. Bimodal spawning is typical for channel catfish, and it occurs in lentic (Marzolf, 1957; Deacon, 1961) and lotic environments (Brown and Armstrong,1985; Holland-Bartels and Duval, 1988). We based our estimates of alevin growth and mortality on the data from the first spawning peak to minimize the likelihood of violating the assumption that each size class was equally vulnerable to sampling gear.

We hypothesized that yolk-sac larvae were not in the drift because newly-hatched fish do not leave the nest until 7 or 8 days post-hatch (e.g., Marzolf, 1957). Channel catfish hatch at about 6 - 9 mm TL and generally become abundant in the catch at about 15 mm TL (Lippson and Moran, 1974; Tin, 1982; Armstrong and Brown, 1983; Brown and Armstrong, 1985). Growth from hatch to 15 mm in eight days seems unlikely. Further, 7- or 8-day-old channel catfish were too large to be extruded through our sampling nets. Therefore, we should have collected channel catfish less than 15 mm TL had they been present in the water column. Their absence from the catch suggests that when channel catfish first leave the nest they are not vulnerable to drift nets, or alevins stay in the nest longer than the 7 - 8 days reported, or unexplained mortality is occurring.

Biologists must provide objective inputs to decision making about fisheries (Noble and Jones, 1993) and conservation manipulations. Therefore, biologists must understand fish population dynamics, but these data are lacking for many YOY fishes. Our results suggest that instantaneous growth of alevin channel catfish in the Oconee River is low, and several factors could explain this phenomenon. Further research is needed to ascertain if our results are consistent over larger time scales (i.e., year to year variability) and with other populations. Such data will allow fishery managers to better understand population dynamics of YOY channel catfish in riverine environments and better determine life history components in this commercially, recreationally, and community important species.

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LITERATURE CITED

Armstrong, M.L. and A.V. Brown. 1983. Diel drift and feeding of channel catfish alevins in the Illinois River, Arkansas. Trans. Am. Fish. Soc. 112:302-307.

Balon, E.K. 1975. Terminology of intervals of fish development. J. Fish. Res. Board Can. 32:1663-1670.

Becker, C.G. 1983. Fishes of Wisconsin. University of Wisconsin Press, Madison.

Brandt, S.B., D.M. Mason and E.V. Patrick. 1992. Spatially-explicit models of fish growth rate. Fisheries 17(2):23-35.

Brown, A.V. and M.L. Armstrong. 1985. Propensity of drift downstream among various species of fish. J. Freshwater Ecol. 3;3-17.

Cada, G.F. and G.L. Hergenrader. 1980. Natural mortality rates of freshwater drum larvae in the Missouri River. Trans. Am. Fish. Soc. 109:479-483.

Carlander, K.D. 1969. Handbook of freshwater fishery biology. Volume 1. Iowa State University Press, Ames.

Cloutman, D.G. 1979. Identification of catfish alevins of the Piedmont Carolinas, p. 176-185. *In:* Proceedings of a workshop on freshwater larval fishes. R. Wallus and C. W. Voigtlander (eds). Tennessee Valley Authority, Division of Forestry, Fisheries, and Wildlife Development, Norris, Tennessee.

Crecco, T., T. Savoy and L. Gunn. 1983. Daily mortality rates of larval and juvenile American shad (*Alosa sapidissima*) in the Connecticut River with changes in year-class strength. Can. J. Fish. Aquat. Sci. 40:1719-1728.

Deacon, J.E. 1961. Fish populations, following a drought, in the Neosho and Marais des Cygnes rivers. Publ. Mus. Nat. Hist. Univ. Kansas 13:359-427.

Essig, R.J. and C.F. Cole. 1986. Methods for estimating larval fish mortality from daily increments in otoliths. Trans. Am. Fish. Soc. 115:34-40.

Everhart, W.H. and W.D. Youngs. 1981. Principles of fishery science. Second Edition. Cornell University Press, Ithaca, New York.

Freeberg, M.H., W.W. Taylor and R.W. Brown. 1990. Effects of egg and larval survival on year-class strength of lake whitefish in Grand Traverse Bay, Lake Michigan. Trans. Am. Fish. Soc. 119:92-100.

Hackney, P.A. and J.C. Webb. 1978. A method for determining growth and mortality rates of ichthyoplankton, p. 115-124. *In:* Fourth national workshop on entrainment and impingement. L.D. Jensen (ed.). Ecological Analysts Communications, Melville, New York.

Hatch, J.T. and J.C. Underhill. 1988. Abundance, distribution, growth, and mortality of larval herrings in western Lake Superior, p. 96-103. *In:* 11th Annual Larval Fish Conference. American Fisheries Society Symposium 5. R.D. Hoyt (ed.). Bethesda, Maryland.

Holland-Bartels, L.E. and M.C. Duval. 1988. Variations in abundance of young-of-the-year channel catfish in a navigation pool of the upper Mississippi River. Trans. Am. Fish. Soc. 117:202-208.

Jenkins, R.E. and N.M. Burkhead. 1993. Freshwater fishes of Virginia. American Fisheries Society, Bethesda, Maryland.

Jones, P.W., F.D. Martin and J.D. Hardy. 1978. Development of fishes of the Mid-Atlantic Bight. An atlas of egg, larval and juvenile stages. Volume 1. U.S. Fish and Wildlife Service Biological Services Program FWS/OBS-78/12, Fort Collins, Colorado.

Lippson, A.J. and R.L. Moran, editors. 1974. Manual for identification of early developmental stages of fishes of the Potomac River estuary. Maryland Department of Natural Resources, Power Plant Siting Program, Miscellaneous Publication 13, Annapolis, Maryland.

Marzolf, R.C. 1957. The reproduction of channel catfish in Missouri ponds. J. Wildl. Manage. 21:22-28.

McInerny, M.C. and J.W. Held. 1995. First-year growth of seven co-occurring fish species of Navigation Pool 9 of the Mississippi River. J. Freshwater Ecol. 10:33-41.

Noble, R.L. and T.W. Jones. 1993. Managing fisheries with regulations, p. 383-402. *In:* Inland fisheries management in North America. C.C. Kohler and W.A. Hubert (eds.). American Fisheries Society, Bethesda, Maryland.

Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish population. Fish. Res. Board Can. Bull. 191.

Stokes W.R.,III and R.D. McFarlane. 1995. Water Resources Data, Georgia, Water Year 1995. U.S. Geological Survey Water-Data Report GA-95-1, Atlanta, Georgia.

Tin, H.T. 1982. Family Ictaluridae, bullhead catfishes, p. 436-457. *In:* Identification of larval fishes of the Great Lakes basin with emphasis on the Lake Michigan drainage. Great Lakes Fishery Commission Special Publication 82-3. N.A. Auer (ed.). Ann Arbor, Michigan.

Van Den Avyle, M.J. 1993. Dynamics of exploited fish populations, p. 105-135. *In:* Inland fisheries management in North America. C.C. Kohler and W.A. Hubert (eds.). American Fisheries Society, Bethesda, Maryland.

Wang, J.C.S. and R.J. Kernehan. 1979. Fishes of the Delaware estuaries: a guide to the early life histories. EA Communication, Ecological Analysts, Towson, Maryland.

Zigler, S.J. and C.A. Jennings. 1993. Growth and mortality of larval sunfishes in backwaters of the upper Mississippi River. Trans. Am. Fish. Soc. 122:1080-1087.

Fish Richness and Abundance in Created Riparian Habitats of Channelized Northern Mississippi Streams

PETER C. SMILEY JR.[1], SCOTT S. KNIGHT, CHARLES M. COOPER AND KENNETH W. KALLIES

USDA-ARS National Sedimentation Laboratory
P.O. Box 1157
Oxford, MS 38655

ABSTRACT

Streamside habitats in Mississippi have been impacted by agricultural practices and channel incision. One contributing process to the degradation of riparian habitats adjacent to deeply incised streams is the development of gully erosion. Gully erosion is initiated by storm runoff flowing over high unstable streambanks which result from channel incision. Field-scale grade control structures (drop-pipes) are used to control gully erosion and often result in the creation of small field-level wetlands and stream-level pools. Fish and habitat data were collected from selected field-level wetlands and stream-level pools located in hill lands of Mississippi from May to September 1996. Field-level wetlands contained a total of eight species from 3809 captures; 22 species from 668 captures occurred within stream-level pools. Regression analysis indicated that pool area and depth were associated positively with species richness and numbers per unit effort within field-level wetlands and stream-level pools. Our results suggest that altering the drop-pipe installation design to facilitate the creation of larger and deeper field-level wetlands and stream-level pools will provide even greater benefits for fish and other wildlife.

INTRODUCTION

Streams and rivers of the southeastern United States are recognized as one of 233 regional habitat types which need to be protected to assist with the conservation of global biodiversity (Olson and Dinerstein, 1998). Unfortunately, many streams and rivers within the southeastern United States have been impacted by channel incision (Shields et al., 1998). Riparian zones within northwestern Mississippi most often consist of narrow vegetative corridors lacking riparian wetlands and other aquatic habitats which can serve as important habitats for stream fishes. Agricultural practices and channel incision have contributed to the degradation of riparian habitats within this region since the 1830's. The initial reduction of riparian zone width and vegetation occurred as land immediately adjacent to these waterways was cleared and developed for agriculture. Channel incision was initiated by federal channelization projects conducted between 1930 and 1960 (Shields et al., 1995a). During channel incision, a further reduction of riparian vegetation accompanied the process of bank failure, which was initiated by over-steepening and an increase in streambank heights (Simon and Hupp, 1987). Physical degradation of riparian zones continued with the development of gully erosion, which was initiated by storm runoff flowing over high unstable streambanks formed by channel incision.

Within stream ecosystems, protection and restoration of riparian zones should be one of the highest biological priorities because of the complex physical and biotic interactions which occur at this land-water interface (Dickson and Warren, 1994). Despite this importance, most restoration projects within incised streams fail to consider riparian zone restoration and focus on the creation of in-stream habitat (Brookes et al., 1996). Additionally, past research on restoration efforts of incised streams in northwestern Mississippi has only examined the responses of stream fish communities to alterations of in-stream habitats (Cooper and Knight, 1987; Shields et al., 1995; Shields et al., 1995b; Shields et al., 1997; Shields et al., 1998). Field-scale grade control structures (drop-pipes) (Fig. 1) are the most common erosion control devices installed as part of the Demonstration Erosion Control (DEC) project in the Yazoo River basin and are used to control gully erosion occurring adjacent to incised streams (Shields et al., 1995a). Installing drop-pipes results in replacement of eroding gullies with riparian habitats located at the field-level of incised streams and small pools located within the stream channel. Cooper et al.

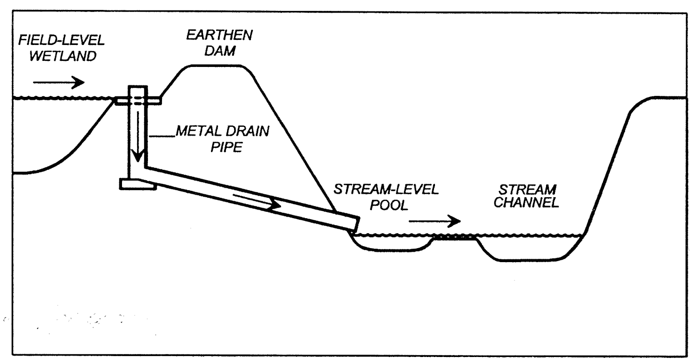

Figure 1. Cross section of drop-pipe structure and created habitat types.

[1]Corresponding author. Present address: Mississippi State University, Department of Wildlife and Fisheries, Box 9690, Mississippi State, MS 39762-9690. pcs1@ra.msstate.edu

(1997) and Smiley et al. (1997) documented that fish occupy field-level wetlands, but no prior research has focused on fish communities of both field-level wetlands and stream-level pools and their associations with selected physical habitat characteristics. Therefore, our objectives for this research were to: 1) describe fish communities associated with aquatic habitats created by drop-pipe installation; 2) determine the relationship of pool surface area and depth with number of fish species (species richness) and numbers per unit effort (NPUE) within drop-pipe created habitats; and 3) evaluate the effectiveness of these structures in habitat creation to assist with restoration efforts within incised streams.

METHODS AND MATERIALS

Habitat Classification

Two types of aquatic habitats that may result from drop-pipe installation are field-level wetlands and stream-level pools. According to prior habitat classification of drop-pipe created habitats, field-level wetlands could include a variety of habitat types ranging from ephemeral to permanent wetlands. In this paper, we focus specifically on the intermittent riverine wetland habitat defined by Cooper et al. (1997) and Smiley et al. (1997). These are permanently inundated unconsolidated bottom wetlands surrounded by agricultural fields and located immediately adjacent to incised streams with streambanks that are nearly vertical in many locations and bank heights that range from 2- to 7-m high (Cooper and Knight, 1991; Shields et al., 1994). These bank heights result in the field-level wetlands being hydrologically isolated from the stream, as overbank flooding is rare (Shields and Cooper, 1994). The source of water for these wetlands is precipitation and storm runoff from watersheds that normally include the agricultural fields. Field-level wetlands are the largest wetlands created by drop-pipe installation. Pool surface area of sampled field-level wetlands ranged from 157.1 to 3282.2 m^2; water depth varied from 0.1 to 2.6 m.

Stream-level pools are small backwater pools located within the channel of the incised stream which are created by outflow from the drainpipe. In general, these pools consist of a scour hole at the pipe's outflow with a narrow channel leading to the stream. During stream base flow conditions, we found variation in the location of the scour hole to range from 0 (immediately adjacent) to 63 m from the stream. Stream-level pools are much smaller than field-level wetlands (range of surface area = 0.1 to 91.0 m^2; range of depth = 0.06 to 1.8 m). Stream-level pools do not exhibit the same degree of isolation as the field-level wetlands because they are located within the stream channel. During moderate runoff events these pools usually are connected with the adjacent stream.

Fish and Physical Habitat Data Collection Methods

Fish communities and physical habitats were sampled from 12 field-level wetlands and 36 stream-level pools located within Hotophia, Long, and Otoucalofa creek watersheds. These three watersheds are part of the Yazoo River basin and are located in northwestern Mississippi along the bluffline bordering the Mississippi River alluvial plain (Shields et al., 1995c) (Fig. 2). Fish and habitat data were collected from field-level wetlands in May 1996; stream-level pools were sampled from June to September 1996. The discrepancy in number of sites sampled between field-level wetlands and stream-level pools is indicative of the availability of sites, not sampling effort. Prior to initiating this study, selected sites of both habitat types were sampled by electroshocking and seining. Seining (15.2 m, mesh size 0.9 cm or 6.1 m, mesh size 0.3 cm) was the most effective sampling technique for field-level wetlands and electroshocking was the most effective within stream-level pools. Sampling the entire habitat within field-level wetlands was impractical due to their large size and depth. However, all microhabitats within each site were sampled and the mean collecting effort was 3.1 seine hauls (SE = 0.52). The smaller seine was only used at one site where an excessive amount of woody debris made sampling with the larger seine ineffective. Due to potential differences in capture efficiency of the two seines, only NPUE calculated from sites sampled with the larger seine were used in the regression analyses. Stream-level pools were sampled with a Coffelt BP-4 backpack-mounted electroshocker and our mean sampling effort was 5.6 minutes (SE = 0.72) of electroshocking. The small size of these pools enabled us to sample each pool completely.

All identifiable fish were enumerated and released at the site of capture. Fish unidentifiable in the field were preserved in 10% formalin solution and returned to the laboratory for subsequent identification and enumeration. Pool surface area was obtained by first determining the shape of each pool (circle, rectangle, square, or triangle) and then physical dimensions (length, width, height) necessary to calculate surface area were measured using a tape measure. Maximum pool depths were measured to the nearest centimeter using either a meter stick or a 2.7 meter pole, which was marked in increments of centimeters. Measurements of surface area and maximum pool depths were obtained at the time of fish collection.

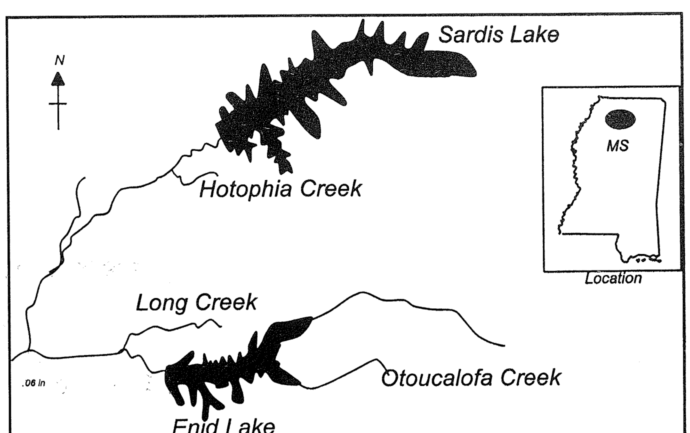

Figure 2. Location of study sites.

Statistical Analysis

A t-test was used to compare species richness between field-level wetlands and stream-level pools. Species richness values were log (x+1) transformed prior to analysis to meet the assumptions of normality and equal variance (Zar, 1984). Due to differences in capture efficiency between sampling techniques, no statistical comparisons were made for mean number of captures and mean NPUE between field-level wetlands and stream-level pools. However, the means and standard errors were calculated and reported for comparison. A simple regression analysis was used to examine the relationship of surface area and depth with species richness and NPUE. This analysis was preferred to multiple regression because of the occurrence of high multicollinearity between surface area and depth within both field-level wetlands ($r = 0.808$, $P < 0.005$) and stream-level pools ($r = 0.733$, $P < 0.00001$) (Zar, 1984). In all regression analyses, both the independent and dependent variables were log (x+1) transformed prior to analysis (Zar, 1984). The logarithmic transformation of both axes is the most common model utilized to examine species-area relationships (Connor and McCoy, 1979; Halyk and Balon, 1983) and was used to meet the assumptions of normality and equal variance (Zar, 1984).

In addition to surface area and depth, species richness and NPUE within stream-level pools may be influenced by a watershed effect resulting from sampling stream-level pools adjacent to different streams. Variation in distance of the scour hole from the stream may also affect species richness and NPUE within stream-level pools. A single factor analysis of variance was used to test for a watershed effect by comparing species richness and NPUE among stream-level pools from Hotophia, Long, and Otoucalofa Creeks. Pearson's product-moment correlation was used to determine the relationship between distance of scour hole to stream and species richness and NPUE. All statistical tests were conducted using SigmaStat 2.0 for Windows (Jandel Corporation, 1995) statistical software package. Significant results were identified at the $P < 0.05$ level.

RESULTS

Fishes were captured in eight of 12 field-level wetlands and 26 of 36 stream-level pools. A list of all species captured, relative abundance, total number of captures, and frequency of occurrences is provided in Table 1. The four most abundant species captured within both habitat types were green sunfish (*Lepomis cyanellus*), bluegill (*Lepomis macrochirus*), western mosquitofish (*Gambusia affinis*), and golden shiner (*Notemigonus crysoleucas*). Total species richness of field-level wetlands was eight from 3809 captures; a total of 22 species from 668 captures occurred within stream-level pools. Stream-level pools exhibited a slightly higher, but not significantly higher ($P = 0.229$), mean species richness than field-level wetlands. Field-level wetlands exhibited a greater mean number of captures and mean NPUE (Table 2).

Regression analyses revealed a significant positive relationship between pool surface area and depth with species richness and NPUE within both field-level wetlands and stream-level pools (Table 3). A watershed effect on species richness ($F_{2, 23} = 0.674$, $P > 0.05$) or NPUE ($F_{2, 21} = 0.437$, $P > 0.05$) within stream-level pools was not detected. Additionally, no significant correlation was observed between distance to scour hole from stream with species richness ($r = -0.024$, $P > 0.05$) or NPUE ($r = 0.007$, $P > 0.05$).

DISCUSSION

Fish use of both field-level wetlands and stream-level pools indicates the potential of aquatic habitat creation by drop-pipe installation. Installation of this structure can result in the development of habitats characterized by either permanent inundation (field-level wetlands) or periodic connections with an adjacent waterbody (stream-level pools). It is necessary for created habitats to possess at least one of these physical characteristics to maintain water quality levels suitable for the physiological requirements of fishes.

Comparisons among created habitats reveal that fish communities within field-level wetlands are characterized by low total species richness and high numerical abundance, while stream-level pools typically exhibit a higher total species richness and reduced numerical abundance. Variation in total species richness between field-level wetlands and stream-level pools may be attributed to differences in degree of isolation from the active stream channel between the two habitat types. Both field-level wetlands and stream-level pools contained individuals of fish species commonly found in both lentic and lotic systems (bluegill, green sunfish). Stream-level pools contained individuals of 10 species typically found only in streams [creek chubsucker (*Erimyzon oblongus*), creek chub (*Semotilus atromaculatus*), bluntnose minnow (*Pimephales notatus*), redfin shiner (*Lythrurus umbratilis*), striped shiner (*Luxilus chrysocephalus*), brook silverside (*Labidesthes sicculus*), Yazoo shiner (*Notropis rafinesquei*), river carpsucker (*Carpiodes carpio*), emerald shiner (*Notropis atherinoides*), and bluntface shiner (*Cyprinella camura*)] (Table 1). These species are also present within Hotophia, Long, and Otoucalofa creeks (Knight and Cooper, 1987; Shields et al., 1994) and their presence within stream-level pools implies periodic connections with these streams. Additionally, variability in fish abundance among created habitats may be a result of pool size as the smallest field-level wetland sampled was 1.7 times greater in surface area than the largest stream-level pool sampled.

The creation of aquatic habitats within impacted riparian zones is an important step towards mitigating the detrimental effects of channel incision and gully erosion. The degree of isolation of field-level wetlands may prevent this habitat type from directly contributing to recovery of the adjacent incised stream fish community. However, fish communities within field-level wetlands may contribute to the stream corridor ecosystem by serving as a food resource for other riparian

Table 1. Species list, overall relative abundance (percent), total number of captures (number), and frequency of occurrence (frequency) for each created habitat type within eight field-level wetlands and 26 stream-level pools.

Species	Percent	Number	Frequency
Field-level wetland fish species			
Lepomis cyanellus (green sunfish)	46.9	1788	7
Gambusia affinis (western mosquitofish)	22.5	856	1
Notemigonus crysoleucas (golden shiner)	20.0	762	5
Lepomis macrochirus (bluegill)	8.1	307	3
Pomoxis nigromaculatus (black crappie)	1.0	39	1
Ameiurus natalis (yellow bullhead)	0.7	25	1
Ameiurus melas (black bullhead)	0.4	16	3
Micropterus salmoides (largemouth bass)	0.3	10	1
Lepomis hybrid (hybrid sunfish)	0.2	6	1
Stream-level pool fish species			
Lepomis cyanellus (green sunfish)	31.6	211	19
Lepomis macrochirus (bluegill)	16.9	113	12
Gambusia affinis (western mosquitofish)	9.0	60	9
Notemigonus crysoleucas (golden shiner)	8.4	56	10
Erimyzon oblongus (creek chubsucker)	7.5	50	10
Semotilus atromaculatus (creek chub)	6.4	43	11
Fundulus olivaceus (blackspotted topminnow)	6.1	41	13
Lepomis megalotis (longear sunfish)	2.5	17	6
Micropterus punctulatus (spotted bass)	2.2	15	6
Dorosoma cepedianum (gizzard shad)	1.9	13	3
Ameiurus natalis (yellow bullhead)	1.5	10	5
Pimephales notatus (bluntnose minnow)	1.2	8	3
Lythrurus umbratilis (redfin shiner)	1.0	7	2
Luxilus chrysocephalus (striped shiner)	0.7	5	2
Labidesthes sicculus (brook silverside)	0.6	4	1
Notropis rafinesquei (Yazoo shiner)	0.6	4	1
Carpiodes carpio (river carpsucker)	0.3	2	2
Notropis atherinoides (emerald shiner)	0.3	2	1
Cyprinella camura (bluntface shiner)	0.3	2	1
Pomoxis nigromaculatus (black crappie)	0.3	2	1
Aphredoderus sayanus (pirate perch)	0.1	1	1
Lepomis gulosus (warmouth)	0.1	1	1
Lepomis hybrid (hybrid sunfish)	0.1	1	1

Table 2. Mean species richness, mean number of captures, and mean NPUE within eight field-level wetlands and 26 stream-level pools. Numbers in parentheses are standard errors.

Habitat type	Species richness	Number of captures	NPUE
Field-level wetland	2.9 (0.5)	528.9 (187.0)	162.9 (69.8)
Stream-level pool	4.6 (0.6)	25.7 (6.0)	3.9 (0.6)

Table 3. Regression analyses of species richness and NPUE on pool area and depth for field-level wetlands and stream-level pools created by drop-pipe installation. Independent variable (x), dependent variable (y), *Y* intercept, slope, coefficient of determination (R^2), and significance levels. P values less than 0.05 are significant.

Habitat type	x	y	Intercept	Slope	R^2	P
Field-level wetland	area	species richness	-1.323	0.554	0.449	0.017
	depth	species richness	-0.846	0.642	0.534	0.011
	area	NPUE	-3.789	1.646	0.337	0.048
	depth	NPUE	-2.499	1.981	0.428	0.029
Stream-level pool	area	species richness	-0.143	0.540	0.468	<0.001
	depth	species richness	-0.022	2.031	0.368	<0.001
	area	NPUE	-0.102	0.476	0.316	<0.001
	depth	NPUE	0.112	1.369	0.134	0.043

vertebrate species (Halyk and Balon, 1983), such as snapping turtles (*Chelydra serpentina*), raccoons (*Procyon lotor*), and wading birds (Family Ardeidae) which utilize field-level wetlands (Cooper et al., 1997).

Stream-level pools, in contrast, have potential to directly benefit stream fish communities impacted by channel incision and gully erosion. Incised streams exhibit decreased habitat quality and are lacking in pool habitats (Shields et al., 1998). Natural pools within incised streams are transient habitat features which undergo several fill and scour cycles annually due to shifting sand beds resulting from increased sedimentation loads (Cooper and Knight, 1987). Restoration structures that facilitate the development of pool habitats can benefit fish communities within incised streams. Currently, common restoration structures utilized by the DEC project within the Yazoo River Basin result in creation of variably-sized pools within the stream channel (Cooper and Knight, 1987; Shields et al., 1998). Drop-pipe installation that results in the creation of backwater habitats (stream-level pools) also increases habitat diversity as this habitat type is lacking within incised streams. In addition, stream-level pools may provide refugia during flooding events because they are located adjacent to the main channel, not within it. Refugia are important for fish communities within incised streams as these ecosystems experience harsher environmental conditions than non-incised streams because all flood waters are contained within the enlarged stream channel during storm events (Matthews, 1986).

In conclusion, potential restoration benefits of drop-pipe installation have yet to be realized because these environmental improvements occurred as a result of standard installation practices which focus on erosion control without consideration of habitat creation. These results and others (Cooper et al., 1997; Smiley et al., 1997) suggest that consideration of habitat creation during drop-pipe installation will benefit not only fish communities, but all vertebrate species inhabiting riparian zones of deeply incised streams. Specifically, modifications to the installation design that result in increased pool size of both created habitat types would benefit fish communities. During low flow conditions, some stream-level pools were isolated from the stream because the narrow channel connecting the stream-level pool to the adjacent stream dried up. Therefore, modifications which would improve connectivity of created stream-level pools with the adjacent stream, such as enlarging the narrow channel, may result in increased fish usage of stream-level pools. Furthermore, many field- and stream-level pools possessed little or no canopy cover. Replanting native riparian vegetation would provide increased canopy cover and leaf input that would benefit fish communities within the created habitats. Future research is needed to evaluate the benefits of the latter two recommendations and to explore the ecological impacts of other potential modifications to the drop-pipe installation design.

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LITERATURE CITED

Brookes, A., S.S. Knight, and F.D. Shields, Jr. 1996. Habitat enhancement, p. 103-126. *In*: River channel restoration: guiding principles for sustainable projects. A. Brookes and F.D. Shields, Jr. (eds.). John Wiley and Sons, Chichester, UK.

Connor, E.F. and E.D. McCoy. 1979. The statistics and biology of species-area relationship. Am. Nat. 113:791-833.

Cooper, C.M. and S.S. Knight. 1987. Fisheries in man-made pools below grade-control structures and in naturally occurring scour holes of unstable streams. J. Soil Water Cons. 42:370-373.

Cooper, C.M. and S.S. Knight. 1991. Water quality cycles in two hill land streams subjected to natural, municipal, and non-point agricultural stresses in the Yazoo Basin of Mississippi, USA (1985-1987). Int. Assoc. Theor. Applied Limnol. 24:1654-1663.

Cooper, C.M., P.C. Smiley, Jr., J.D. Wigginton, S.S. Knight and K.W. Kallies. 1997. Vertebrate use of habitats created by installation of field-scale erosion control structures. J. Freshwater Ecol. 12:199-207.

Dickson, J.G. and M.L. Warren, Jr. 1994. Wildlife and fish communities of eastern riparian forests, p. 1-31. *In*: Riparian Ecosystems in the Humid U.S. Functions, Values, and Management. National Association of Conservation Districts, Washington, DC.

Halyk, L.C. and E.K. Balon. 1983. Structure and ecological production of the fish taxocene of a small floodplain system. Can. J. Zool. 61:2446-2464.

Jandel Corporation. 1995. SigmaStat for Windows version 2.0 statistical software. San Rafael, CA.

Knight, S.S. and C.M. Cooper. 1987. Fishes of Otoucalofa Creek, Mississippi prior to major channel modifications. J. Miss. Acad. Sci. 22:31-38.

Matthews, W.J. 1986. Fish faunal structure in an Ozark stream: stability, persistence, and a catastrophic flood. Copeia 1986:388-397.

Olson, D.M. and E. Dinerstein. 1998. The Global 200: a representation approach to conserving the earth's most biologically valuable ecoregions. Conserv. Biol. 12:502-515.

Shields, F.D., Jr. and C.M. Cooper. 1994. Riparian wetlands and flood stages, p. 351-355. *In*: Hydraulic engineering '94. Proceedings of the 1994 Conference, Hydraulics Division/ASCE.

Shields, F.D., Jr., C.M. Cooper and S.S. Knight. 1995. Experiment in stream restoration. J. Hydraulic Engineering 121:494-502.

Shields, F.D., Jr., S.S. Knight and C.M. Cooper. 1994. Effects of channel incision on base flow stream habitats and fishes. Env. Manage. 18:43-57.

Shields, F.D., Jr., S.S. Knight and C.M. Cooper. 1995a. Rehabilitation of watersheds with incising channels. Water Resources Bull. 31:971-982.

Shields, F.D., Jr., S.S. Knight and C.M. Cooper. 1995b. Incised stream physical habitat restoration with stone weirs. Regulated Rivers: Research and Management 10:181-198.

Shields, F.D., Jr., S.S. Knight and C.M. Cooper. 1995c. Use of the index of biotic integrity to assess physical habitat degradation in warmwater streams. Hydrobiologia 312:191-208.

Shields, F.D., Jr., S.S. Knight and C.M. Cooper. 1997. Rehabilitation of warmwater stream ecosystems following channel incision. Ecol. Engineering 8:93-116.

Shields, F.D., Jr., S.S. Knight and C.M. Cooper. 1998. Rehabilitation of aquatic habitats in warmwater streams damaged by channel incision in Mississippi. Hydrobiologia 382:63-86.

Simon, A. and C.F. Hupp. 1987. Geomorphic and vegetative recovery processes along modified Tennessee streams: an interdisciplinary approach to distributed fluvial systems, p. 251-262. *In*: Forest Hydrology and Watershed Management. Proceedings of the Vancouver Symposium, IAHS-AISH Publ. No. 167.

Smiley, P.C., Jr., C.M. Cooper, K.W. Kallies, and S.S. Knight. 1997. Assessing habitats created by installation of drop pipes, p. 903-908. *In*: Proceedings of the Conference on Management of Landscapes Disturbed by Channel Incision. S.S.Y. Wang, E.J. Langendoen and F.D. Shields, Jr. (eds.). Center for Computational Hydroscience and Engineering, University of Mississippi.

Zar, J.H. 1984. Biostatistical analysis. Prentice Hall, New Jersey. 718 p.

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